# 35. Grazing exclusion and rotational grazing

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## 1. Description of the practice

Overgrazing in poorly managed agricultural areas is a debateable concept based on the equilibrium between biomass production and livestock demand, and degradation of grassland. A strong indicator of overgrazing is the necessity for additional feeds to be brought in from outside the farm to support livestock. Overgrazed, often degraded, areas commonly show a reduction in plant species diversity (and sometimes spread of invasive species of non-native plants and of weeds), productivity, canopy cover, soil structure and soil nutrients. Sustainable grassland management can restore these degraded areas, and thus is an issue to maintaining animal production and the health of the grassland ecosystem (Conant, Paustian and Elliott, 2001; Dong *et al.*, 2015). Low- to medium stocking rates generally contribute to maintaining sufficient vegetation cover to feed livestock and help limit soil degradation processes (e.g. C depletion, nutrient losses, erosion). Hence, regulating grazing intensity and periodic grazing exclusion with fenced paddocks are effective practices for grassland restoration (McSherry and Ritchie 2013; Davies *et al.*, 2014). Previous studies have indicated that periodical grazing exclusion is an effective way to stimulate soil nutrient content through aboveground biomass and root biomass, which act as primary input sources to the soil (Liu, 2016; Sun *et al.*, 2014).

Grazing exclusion can have various durations, from short-term (1 year) to several years depending on the severity of degradation, vegetation type and pedo-climatic zone (Li *et al.*, 2018, Wang *et al.*, 2018). Short- to medium-term exclusion strengthens above- and belowground biomass only, while longer periods of grazing exclusion lead to greater improvements in soil properties, as a new equilibrium can be reached after a few decades (Wang *et al.*, 2018, Dong *et al.*, 2020). Exclusion can be managed by "shifting" livestock systematically at desirable intervals to different subunits of a range area or fenced subdivisions, where some are unmanaged when excluded from grazing. This is called rotational grazing (i.e. adaptive multi paddock grazing) which, under low- to medium- intensity, has been proposed as an alternative to severe grazing exclusion in order to enhance grassland SOC stocks, maintain ecosystem sustainability (Davies *et al.*, 2014; Sanjari *et al.*, 2008), and encourage vegetation (self-)recovery (e.g. seed recolonization through seed maturity) (Briske *et al.*, 2011). Exclusion through set aside (unmanaged) may be combined with restoration to improve plant species pool and diversity (Andrade *et al.*, 2015)

## 2. Range of applicability

Overgrazing is a key factor in soil and plant degradation, particularly in semi-arid and arid rangelands where plant communities are often composed of a majority of grazing resistant shrubs. About 20 percent of global pasture and 73 percent of the rangelands in the drylands have been degraded (Steinfeld, Wassenaar and Jutzi, 2006) in last decades. Due to variability in rainfall and the short growing periods these areas are not suitable for intensive agriculture and the main land use is grazing based mostly on native vegetation cover. Analyses in several dry countries showed that, livestock numbers increased by 20 percent (Steinfeld *et al.*, 2006) without changes in areas under grazing. As a result, the increase in stock numbers has been one of the main causes of land degradation in these low productive lands, for example Central Asian countries, Mongolia, Africa, Australia and US, affecting high percentages of arid lands (Jafari *et al.*, 2008, Zhao, Li and Qi, 2007). Besides the degradation of vegetation in dry areas, exclusion may be used for the protection of water quality in other sensitive areas such as streambanks, riparian areas, uplands and wetlands order to achieve environmental improvements (EPA, 2003). Depending on severity of degradation, attained area, vegetation type and pedo-climatic conditions, grazing exclusion can have different forms; short to long-term exclusion, combined with low rotational grazing and restoration actions (e.g. Tessema *et al.*, 2020).

## 3. Effects on soil organic carbon stocks

Globally, grazing exclusion is an effective management practice to restore degraded grasslands and improve soil quality (i.e. C density and soil C stocks). However, soil restoration on degraded soils, in particular sandy soil, is a slow process, although vegetation can recover rapidly after removal of livestock disturbance (Wang et al., 2018). Soil N is a key factor in the regulation of soil C sequestration in long term grazing exclusion (> 20 years), with higher C accrual in soils with higher N availability. For that reason, in nutrient poor and long-term grazing degraded areas, the recovery of already weakened SOC is very slow (e.g. semi-arid typical steppes, Cui et al., 2005). Table 154 provides some figures of SOC sequestration enabled by grazing exclusion or rotational grazing.

**Table 154.** Evolution of SOC stocks with grazing exclusion of rotational grazing

| Location | Climate zone | Soil type | Baseline C stock (tC/ha) | Additional C storage (tC/ha/yr) | Depth (cm) | Duration (Year) | More information | Reference |
|---|---|---|---|---|---|---|---|---|
| Global | wet, mesic, dry temperate, tropical, subtropical regions | Various | NA | 0.3 to 0.7 | NA | NA | Strong relation to rainfall: annual rainfall from 333 to < 1 800 mm | Conant and Paustian (2002) |
| China | Various | Various | NA | 0.27<br>0.23<br>0.18 | 0-10<br>10-20<br>20-30 | 27 | Grazing exclusion;<br>Strong relation to rainfall | Deng *et al.* (2017), Wang *et al.* (2018) |
| Inner Mongolia, China | Continental semi-arid monsoon temperate | Cambic Arenosol (sandy) | 7.3<br>(0-20 cm)<br>56<br>(0-100 cm) | 0.14 | NA | 25 | Grazing exclusion;<br>Analyses for 3 periods: 7, 12 and 25 years | Li *et al.* (2012) |
| | | Kastanozem | NA | 0.4 to 0.37 | 0-10 | 21-35 | Grazing enclosure vs. rotational grazing (labile SOC stocks) | Dong *et al.* (2020) |
| Chepareria, Kenya | Semi-arid sub-Saharan | NA | 26.1 | 3.1 | 0-100 | 10 | Live fences for rotational grazing | Svanlund (2014) in Tessema *et al.* (2020) |

# 4. Other benefits of the practice

## 4.1. Improvement of soil properties

Changes in ground cover characteristics also improve soil properties such as bulk density, SOC and total N concentration, which are usually good indicators of good grazing management on soils (Wang *et al.*, 2018; Dong *et al.*, 2020; Mchunu and Chaplot, 2012).

## 4.2. Minimization of threats to soil functions

**Table 155**. Soil threats

| Soil threats | |
|---|---|
| **Soil erosion** | Overgrazing reduces coarseness in surface soil, therefore increasing soil losses by wind and water erosion (Golluscio *et al.*, 2009). Restoration of permanent vegetation cover improves soil structure and prevents soil *surface* runoff (Petz *et al.*, 2014). |
| **Nutrient imbalance and cycles** | Improved nutrient use and cycling trough vegetation recovery (Pei *et al.*, 2008; Su *et al.*, 2005). |
| **Soil salinization and alkalinization** | Conservation of vegetation cover without nutrient inputs avoids alkalinization. |
| **Soil biodiversity loss** | Above-ground species diversity influences below-ground diversity (Golluscio *et al.*, 2009). The increased level of soil fertility from grazing exclusion promotes biodiversity restoration and plant growth. |
| **Soil compaction** | Cessation of grazing avoid damages by trampling. |
| **Soil water management** | Conservation of vegetation cover fosters a better water retention capacity and infiltration rate and prevents from *water* runoff and preserves water quality. |

### 4.3. Increases in production (e.g. food/fuel/feed/timber/fibre)

Grazing exclusion often leads to encroachment of unpalatable shrubs into grasslands, which can decrease the livestock carrying capacity over time. However, adaptive multi-paddock grazing can provide the flexibility needed to incorporate management practices such as fire into grazing systems (Teague *et al.*, 2010). Even so, native or selected introduction of shrubs, including drought-tolerant species and nitrogen-fixing legumes, can provide valuable browse for cattle, sheep and goats in arid and semi-arid grazing lands once exclusion is levered.

### 4.4. Mitigation of and adaptation to climate change

Grazing restrictions and exclusions are practices commonly associated with combating soil degradation and SOC losses mostly to overgrazing coupled with drought or wet soils. Restoration of groundcover and nutrient buildup (i.e. in dry soils) can improve soil carbon stocks and water quality (i.e. wet soils), mitigate the risk of erosion (e.g. Petz *et al.* 2014) and limit potential water pollution (EPA, 2003).

### 4.5. Socio-economic benefits

Appropriate grazing management can be a viable solution where the abiotic function of the degraded grazing land has not been irreversibly damaged (Papanastasis, 2009). Implementation of short- to medium- grazing exclusion can be economically interesting as grasslands regain productivity as well as aesthetics, especially when coupled with restoration techniques.

### 4.6. Other benefits

Based on the livestock types and land capacity, grazing exclusion may help to improve species composition and restore biodiversity through regrowth of perennial species (Briske *et al.*, 2011). Also arranging alternative feeds, relocating animals to other areas, and adoption of low-performance animal breeds may restore grassland functions. Accordingly, a combination of several measures such as managing grazing intensity and timing, increasing productivity, management of nutrients, and finding alternatives to the use of shrubs and dung for energy, have implications for socio-economic conditions.

## 5. Potential drawbacks to the practice

### 5.1. Tradeoffs with other threats to soil functions

No trade-offs recorded.

### 5.2. Increases in greenhouse gas emissions

In nutrient poor and long-term grazing degraded areas, the recovery of already weakened SOC is very slow (e.g. semi-arid typical steppes, Cui *et al.*, 2005). In these cases, grazing exclusion coupled with increased soil N supply to grasslands may enhance ecosystem C sequestration during the recovery stage (Deng *et al.*, 2017), but may increase $N_2O$ emission (Schönbach *et al.*, 2012).

### 5.3. Conflict with other practice(s)

The increasing demand for livestock products, results in competition for natural resources, and between food and feed, might lead to priorities that omit arranging alternative feeds and relocation of feed areas.

### 5.4. Other conflicts

Grazing exclusion and possible uncontrolled encroachment of woody species is not desirable, as is the infestation of invasive species. Despite that, introduction of native or selected shrubs can provide valuable feed for livestock once exclusion is levered. Accordingly, more detail analyses are needed to adapt grazing management to regional conditions. For instance, smaller paddocks can improve distribution of animals across a landscape, which can increase or decrease vegetation diversity and soil quality, depending on how animals were previously distributed (see Teague *et al.*, 2013).

## 6. Recommendations before implementing the practice

The effectiveness of grazing management to restore degraded areas is often limited. There is a strong need for adopting sustainable practices at lower intensification management to prevent further soil degradation (Pereira *et al.*, 2017; Davis *et al.*, 2014). Accordingly, better analyses are needed to adapt grazing management to regional conditions. For instance, smaller paddocks can improve distribution of animals across a landscape, which can increase or decrease vegetation groundcover, depending on how animals were previously distributed (see Teague *et al.*, 2013). Also arranging alternative feeds, relocation to other areas, adopt to low-performance animal breeds may allow to restore grassland function. Hence, a combination of several measures in managing grazing, alternatives to the use of shrubs and dung for energy are needed before implementation. These analyses may include diverse knowledge sources for managers, agency professionals, and researchers, to replace the narrow technological approach to grazing systems (see Briske *et al.*, 2011).

## 7. Potential barriers for adoption

Contrasting effects of grazing cessation have been reported when studying similar areas, showing either ameliorating effects or not under short-term exclusion (<5years, e.g. Li *et al.,* 2012). In view of that, implementation is hampered by the absence of generalizable evidence. Furthermore, for low-productivity rangelands (grasslands), the cost of fencing and water systems to enable rotational grazing systems (i.e. including parcels of exclusion) can be prohibitive. For this, an effective implementation of adaptive management would require overcoming institutional barriers and with help of meaningful incentives to promote adoption. To wit, institutional cultures influence behavioural patterns of personnel, approaches to solve problems, and the establishment of goals and priorities. In addition, the decrease in grassland areas due to grazing exclusion may require an increase in concentrated feeds (e.g. feed grains), to supplement fodder. Therefore, it is necessary to consider the total agricultural system and not to restrict the analysis to animal husbandry only (**Table 156**).

**Table 156.** Potential barriers to adoption

| Barrier | YES/NO | |
|---|---|---|
| Social | Yes | Psychological reluctance related consequences of exclusion such e.g. relocation of feed areas, adoption of low-performance animals. |
| Economic | Yes | Contrasting effects of grazing cessation are only detected in the long term (> 12years, Wang *et al.* 2018, Li *et al.* 2012). |
| Legal (Right to soil) | Yes | Lack of supplementary grassland area. |
| Knowledge | Yes | Lack of training, skills, advisory services, supporting tools. |

## Photos of the practice

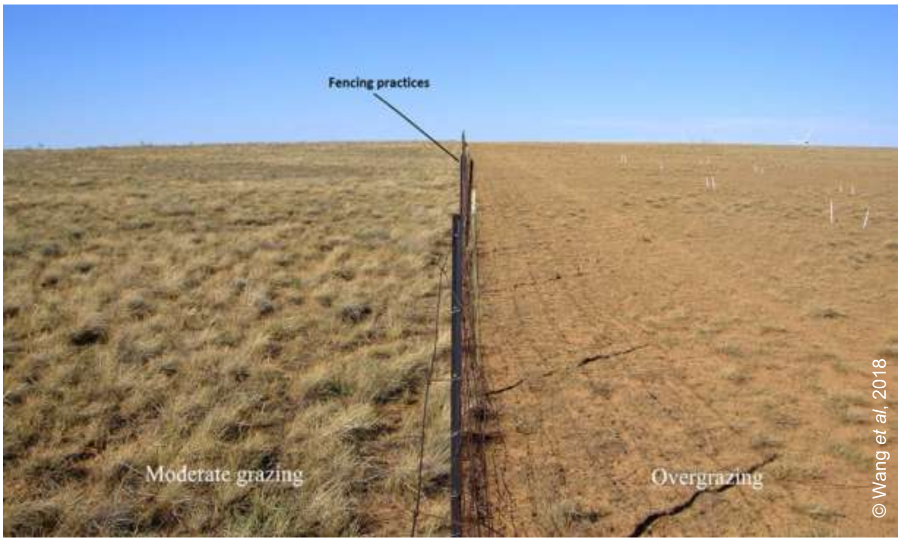



**Photo 44.** Example of moderate and overgrazed area (left) and grazing exclusion (right)

**Table 157.** Related cases studies available in volumes 3 and 5

| Title | Region | Duration of study (Years) | Volume | Case-study No. |
|---|---|---|---|---|
| *Grazing management in rangeland grassland systems in South and East Australia* | Southeast Pacific | 4 to 10 | 3 | 9 |

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